

Analysis of Submarine Groundwater Discharge Discharge to Manila Bay : Density Dependent Hydrogeological Modeling of the South-eastern coastal zone of Bataan, Philippines

- Background
- Study Area
- Methods
- Results and Discussion
- Conclusion

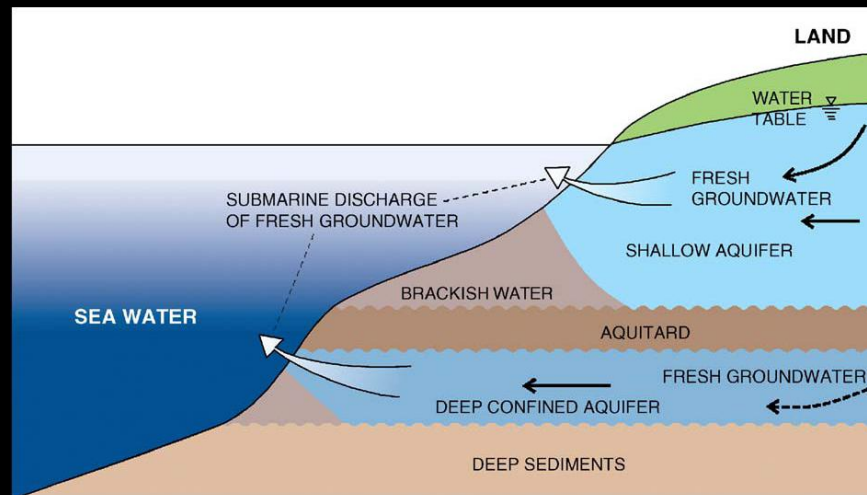


In cooperation with



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The Netherlands

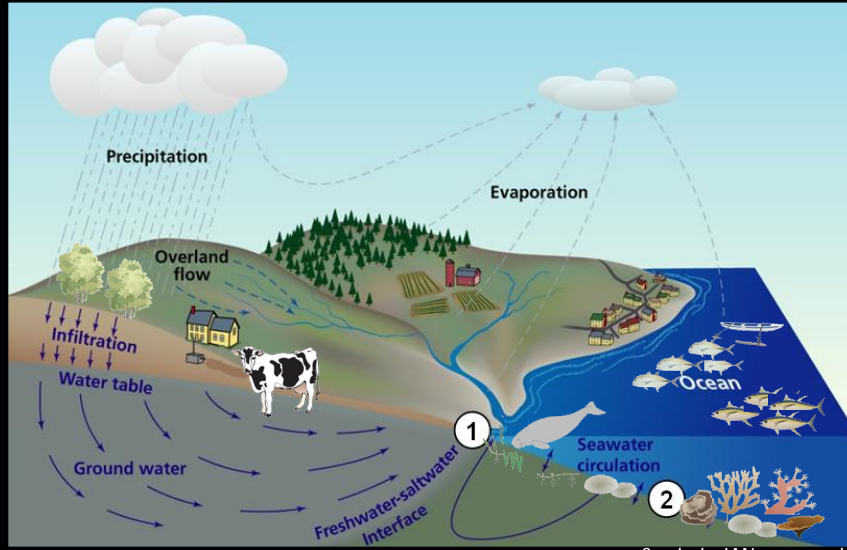
What is Submarine Groundwater Discharge (SGD)?
any flow of water out across the sea floor



Burnett et al, 2006

Why study SGD?

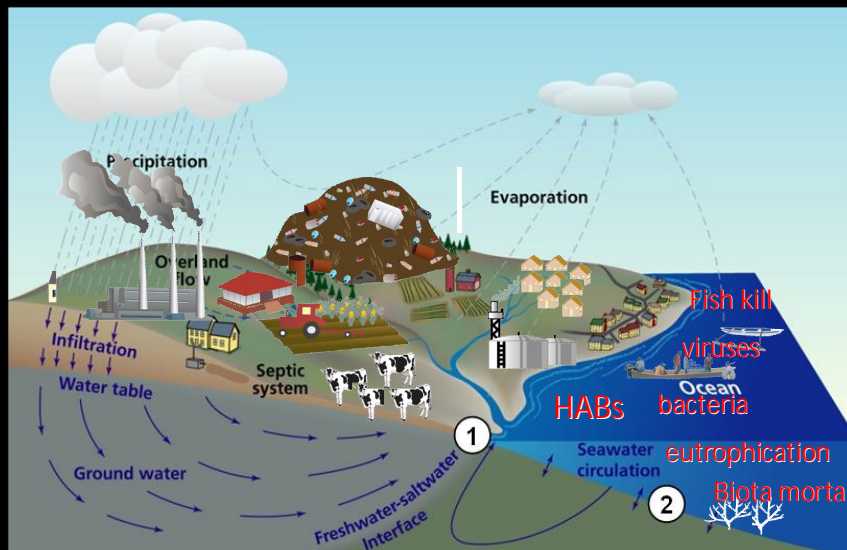
Nutrients are transported from land to sea via SGD pathway



Symbols: IAN.umces.edu

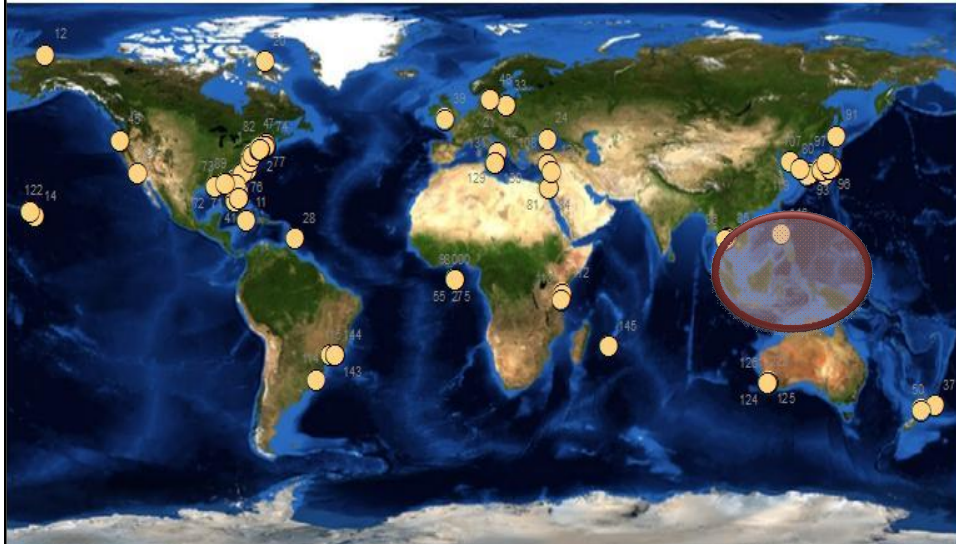
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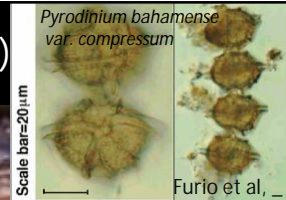
Symbols: IAN.umces.edu

Why the Philippines?



Locations of published studies that have reported SGD estimates

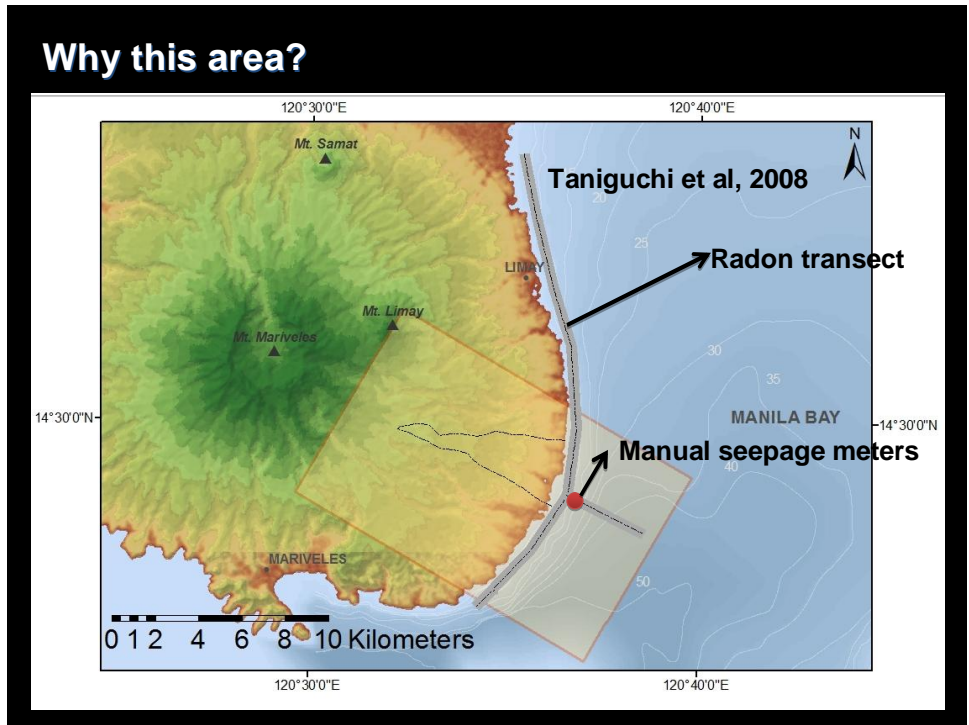
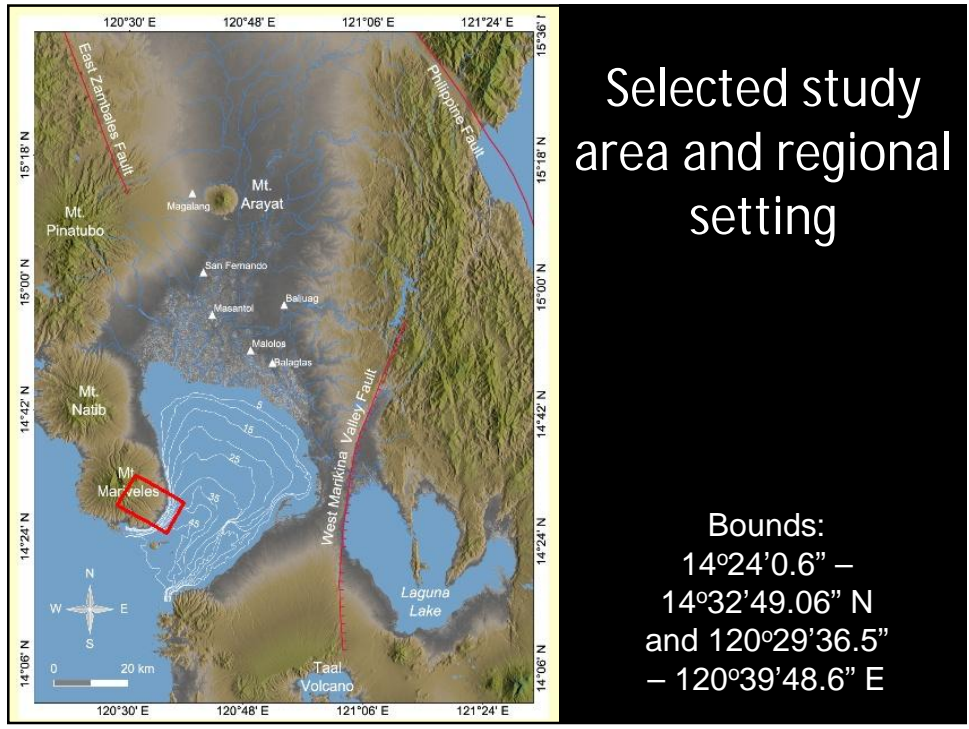
Fish Kill due to Harmful Algal Blooms (HABs) (Relox and Bajarias, 2002)



**00 cases
n deaths
(83-2002)**



Mass mortality of milkfish in Bolinao, Pangasinan due to HABs - 02 Feb 2002



Objective

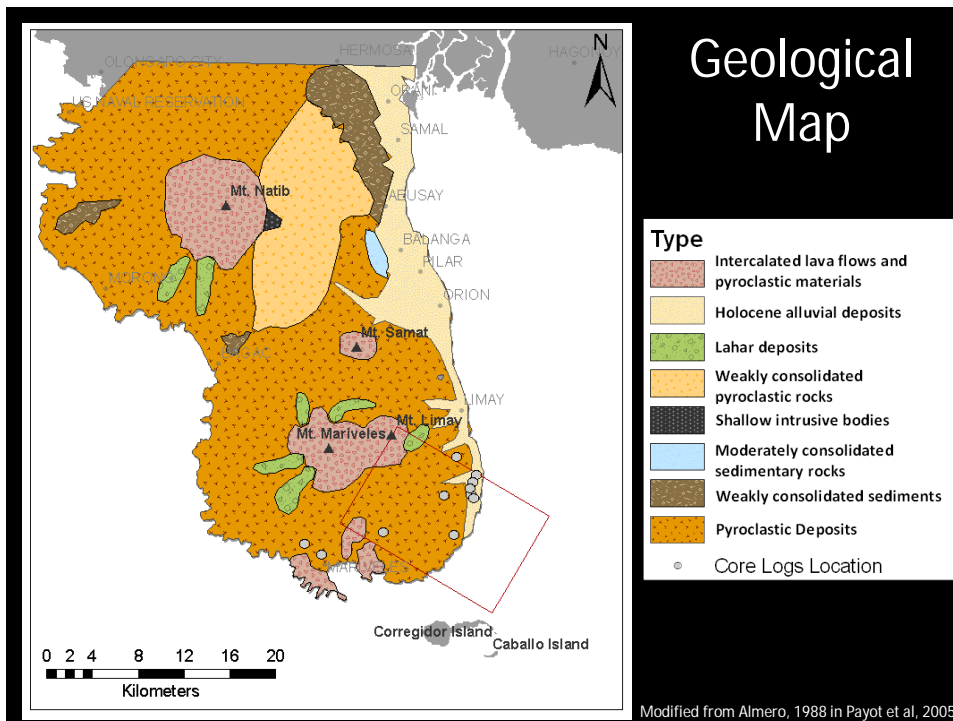
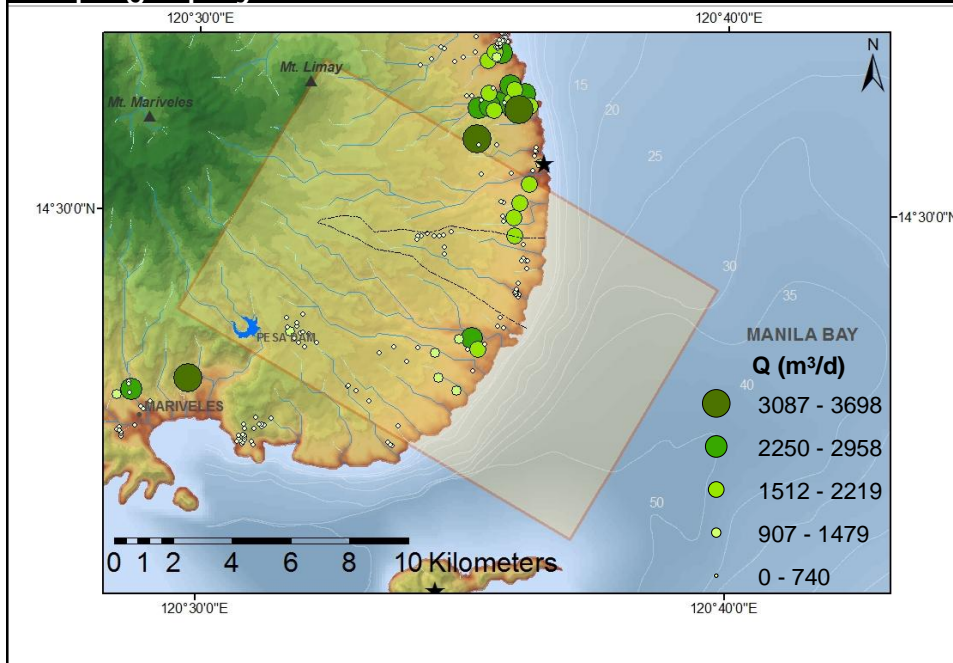
Understand the hydrogeologic factors that influence the SGD flux



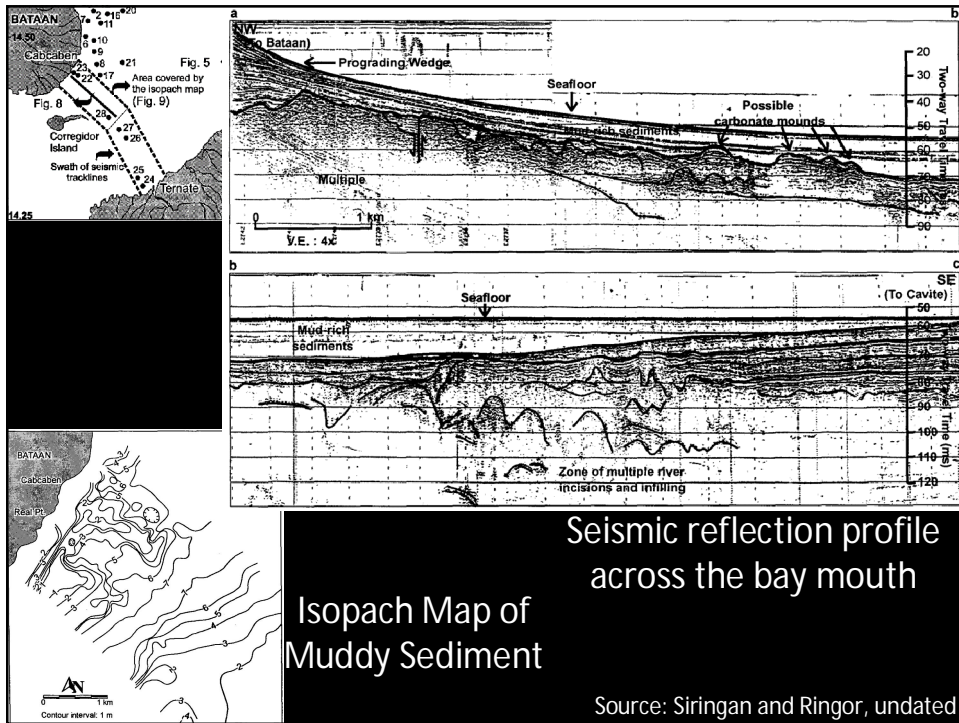
Fieldwork (21-22 July 2009)

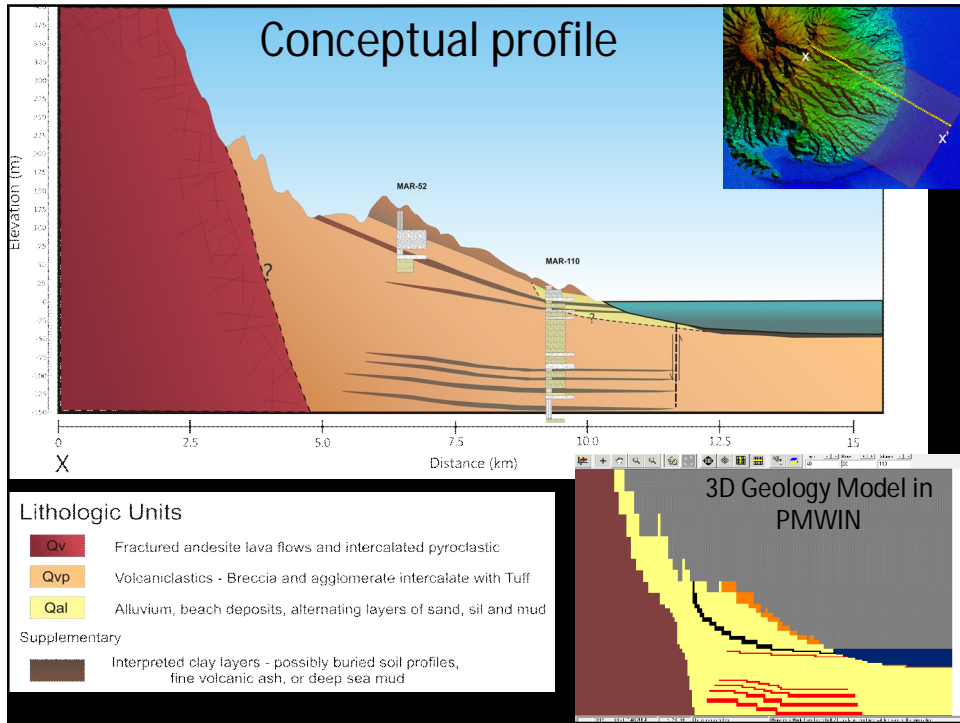


topography rivers rainfall extraction wells



Created x-section logs from bore hole data

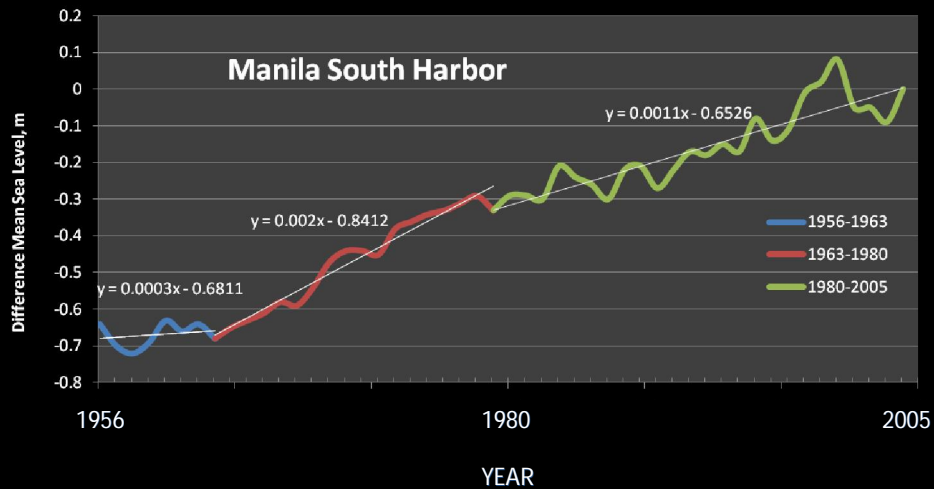




Assigned hydraulic parameters

Symbol	Description	Kh m/d	Data Source
Qv	Fractured lava flows and intercalated pyroclastic	1	Literature Review
Qvp	Volcaniclastics – Breccia and agglomerate intercalated with tuff	4	Pump tests
Qal	Quaternary Alluvium	4	Pump tests
Interpreted Clay layers	1 Surface soil	0.01	Literature review
	2 Buried soil profiles, tuffaceous clay, ash layers	0.001	
	3 Shallow sea mud	0.1	
Anisotropy=10 (assigned for all layers)		Specific Storage for transient model:	
Porosity=0.25 clays=0.1		Ss = 0.00002 (pump tests)	

Sea level



Data Source: NAMRIA data from Geological Oceans Lab, MSI

Model Parameters

Model Area: 9.6 x 15.5 km

Cell size: 100m

Number of model layers: 48

Top: 400m Bottom: -150m

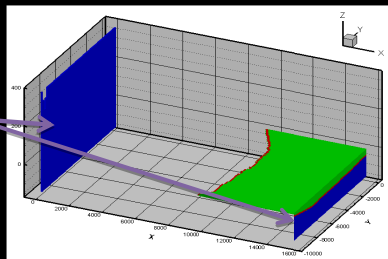
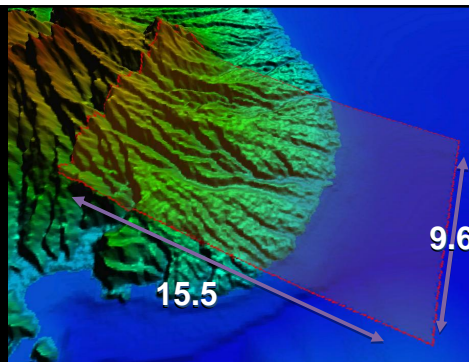
Boundary conditions:

- No flow at N and S edge of model area
- Hydrostatic pressure at land and sea

Modeling Environment: PMWIN

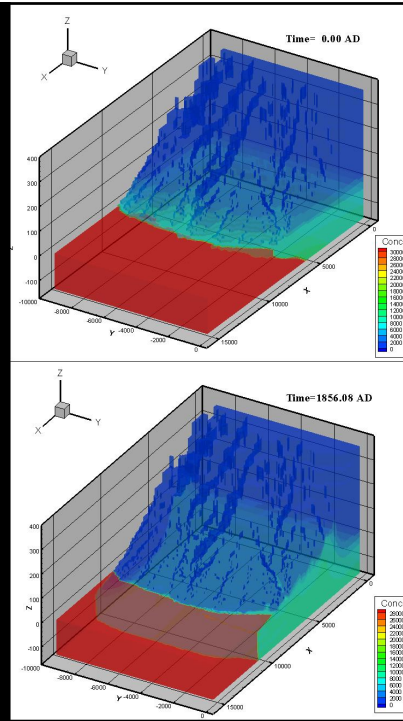
Computer Code: MOCDENS3D

Modifications to MOCDENS3D code: 1) Print only specific stress period;
2) Constant Concentration (35000mgCl) in the sea part



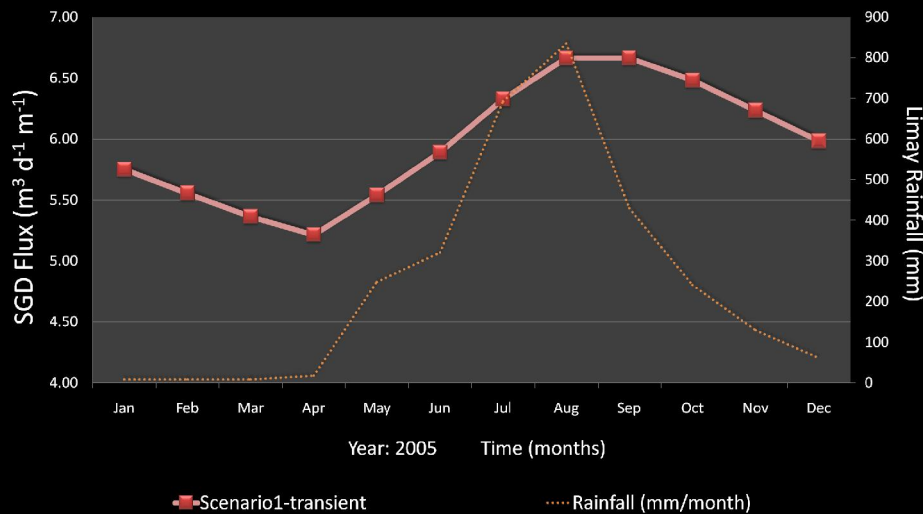
Scenario 1 (base case)

- Part 1 (model spin-up)
 - 150 years (to reach equilibrium)
 - monthly variation
 - no wells
- Part 2
 - 100 years, 1856 – 1956
 - with wells ($Q_{well}/2$)
 - Top sea (-0.6m bmsl)
- Part 3
 - 50 years, 1956 – 2005
 - With full wells
 - Sea level rise

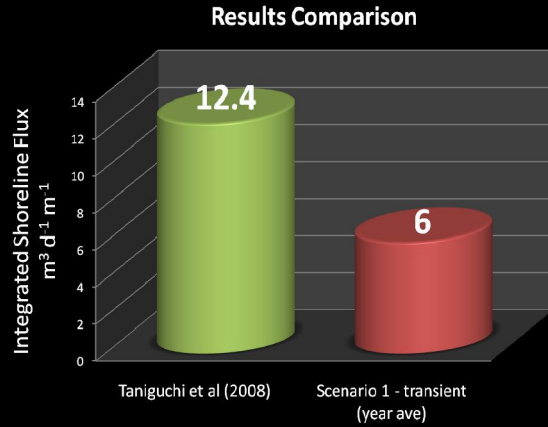


Model Results – Monthly SGD Flux

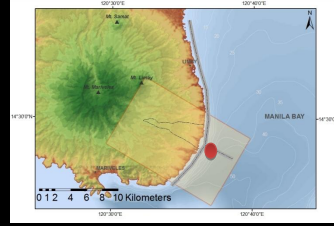
Comparison of SGD flux Model Results - Scenario 1



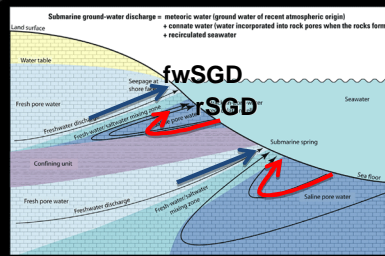
Model Results – SGD flux yr average



1) Difference in area coverage

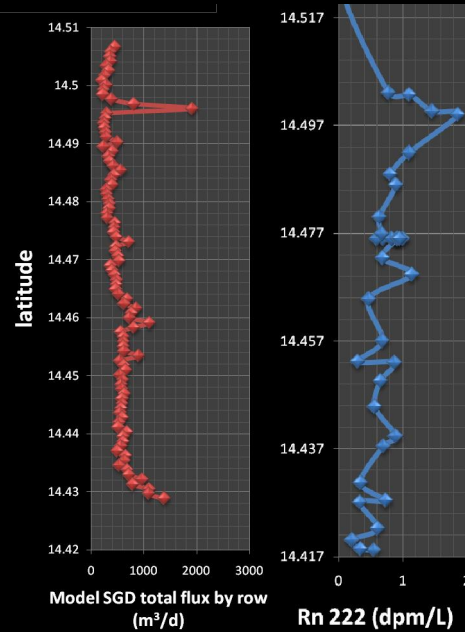


2) $SGD = fwSGD + rSGD$



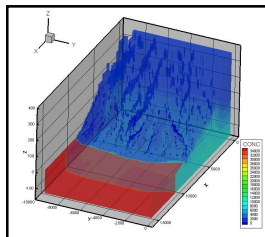
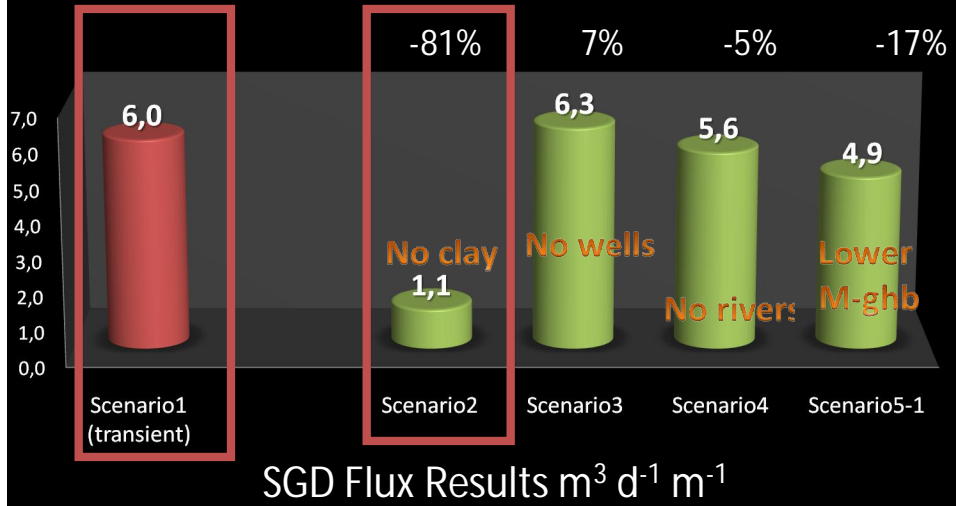
Why the difference?

Model results vs. Radon measurements

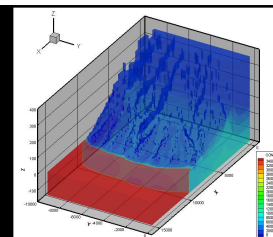


Sensitivity Analysis

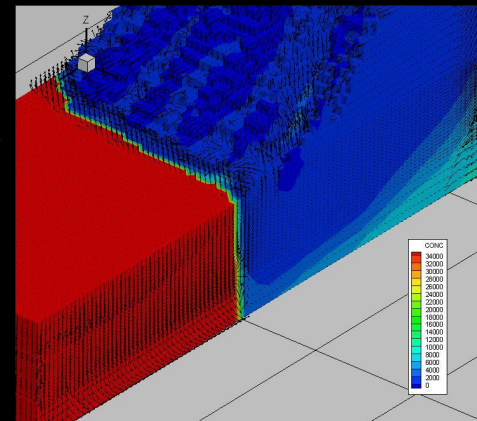
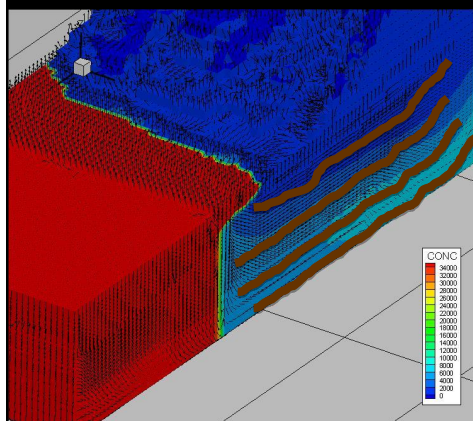
SGD Flux Results % difference



Scenario 1 (base case)



Scenario 2 (no clay case)

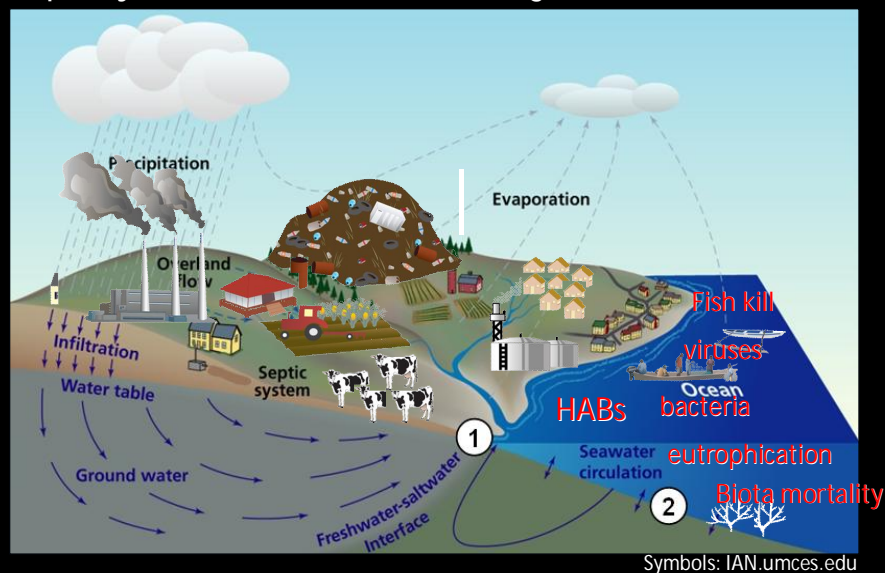


Conclusions and Perspectives

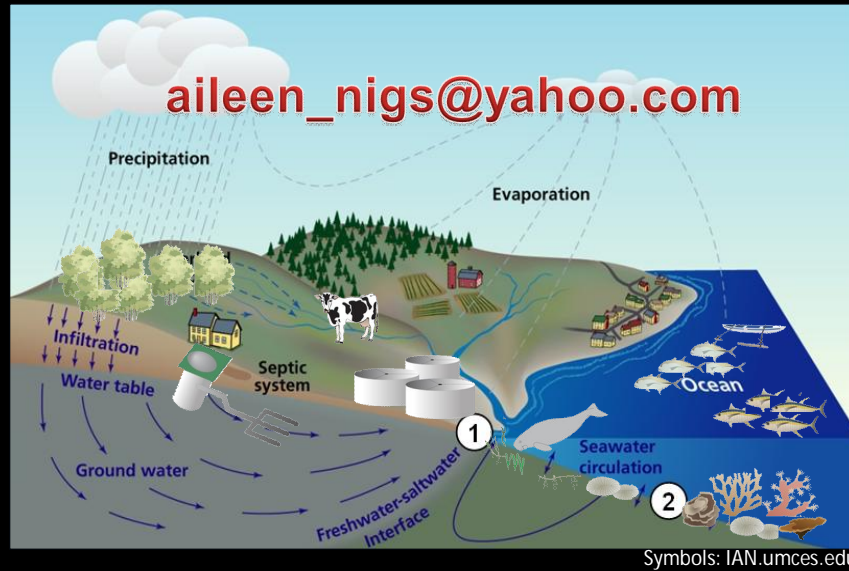
- Model results are consistent with the measured rates
- This is the first 3D approach to represent SGD systems (to our knowledge)
- Even with minimal amount of field data significant results can still be obtained from models
- Continue sensitivity analysis of hydraulic parameters
- Finish climate modeling (ENSO and sea level rise effect)
- Nutrient modeling (reactive transport)

In the future...

For policy makers and coastal managers



Thank you for your attention!



Extra slides for possible questions